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Exploring Women's Experiences of Choosing and Studying Engineering and Navigation: A case study

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ABSTRACT
Women remain underrepresented in UK engineering, constituting only 11% of the engineering workforce in 2017 (WISE, 2017). This paper summarises the findings from two focus groups with twelve participants which explored the experiences of undergraduate women engineering and navigation students at the University of Plymouth. Our aim was to identify ways in which we might support the recruitment, retention and advancement of women in these disciplines. It was possible to identify common experiences to illustrate that women as a group experience engineering and navigation differently from men. Our findings support those of many other studies and include: the 'non-visibility' of engineering as a career option for girls and women and the need to adopt a range of strategies to fit in and claim an authentic identity as an engineer, and not a 'woman engineer'. Additionally, participants were sceptical about initiatives overtly contrived towards helping women to progress in the disciplines as this can be perceived as positive discrimination towards male students and/or there is a concern that male students view them as such. Future research and possible initiatives are discussed.

KEYWORDS
Engineering; Navigation; gender; student experiences; under representation

INTRODUCTION

Engineering careers are potentially highly diverse, rewarding and desirable, yet, women remain underrepresented in UK engineering, constituting only 11% of the engineering workforce in 2017 (WISE, 2017). This is lower than all other European Union countries (UKRC's analysis of the European Labour Force Survey, 2007*)*. This figure is even lower at under 5% for navigation and maritime science. The navigation and maritime science programme offers the route to become a professional seafarer in charge of ships or to work in the shore side maritime sector. At Plymouth, the female students in navigation and maritime science are around 10% which is above the national average. These statistics show that in 40 years, efforts to improve the gender profile in engineering have had limited success. In navigation, efforts to increase female participation have only recently begun.

Although women remain underrepresented in Engineering at all levels, the recruitment, retention and progression of women undertaking Engineering degrees is critical for developing the pipeline of talent for the future.
This has been recognised by the Royal Academy of Engineers (RAEng) and it has undertaken diversity work in the last six years (Designing inclusion into engineering education, 2018; creating cultures where all engineers thrive, 2017; Thinking like an engineer Implications for the education system, 2014) and are actively promoting engineering.

Whilst this is encouraging for female students, it is still true that they often have to cope with a "chilly" environment (Flam, 1991), and feelings of non-belonging (Walton and Cohen, 2007), which can lead to negative wellbeing outcomes (Cohen, Garcia, Purdie-Vaughns, Apfel & Brzustoski, 2009). This potentially leads to a situation where women are succeeding but at a cost, perhaps offering further insight into why large numbers of women continue to be discouraged from pursuing an Engineering career.

A focus group methodology was employed to capture current female students' experiences and attitudes towards engineering and gender. It was our hypothesis that gender would be an important shaping factor in the participant's experiences of engineering in higher education and beyond.

LITERATURE REVIEW

Female under-representation in engineering has been well documented. Efforts to increase the percentage of women in engineering and STEM go back over 30 years, with the inception of WISE in 1983, and as a campaign in 1984. However, numerous subsequent initiatives both from the Royal Academy of Engineering (RAEng) society and other STEM activities have still failed to increase the percentage of females choosing engineering.

Some of the barriers highlighted in research are that STEM subjects can be perceived as difficult to learn (Hulme & de Wilde, 2015, p6) and the difficulty of transitioning between school to higher education (Wakeling & Hampde-Thompson, 2013). Other studies have found that women are attracted to STEM fields which they believe will allow them to help others and benefit society (Freund et al., 2012). Hence women are more likely to choose biomedical and environmental engineering than mechanical or electrical engineering (Ceci and Williams, 2011).

Women also put a higher priority on caring responsibilities and are willing to make occupational sacrifices for it (Hill et al, 2010, Eccles et al 1999 & Hakim, 2006). Traditionally engineering employers have shown less flexibility towards flexible working which has had an impact on retention of women in these fields. In addition, studies by Meyer et al (2015) suggest that in STEM subjects success is believed to require intelligence and talent against a cultural stereotype that women have lower mathematics ability (Bench et al, 2015, Luong and Knobloch-Westerwick 2017; Rea 2015) which is again seen as a barrier for women to succeed in these fields. Despite a number of efforts to change the perception of engineering, it is still male-dominated (Thackeray, 2016), which is again seen as a barrier for females. Further, for women who choose engineering, classroom experiences can serve as a barrier at many levels towards career progression and retention. Women feel that they have to adapt themselves to a traditionally masculine culture (Baxter, 2010), work harder to prove their scientific authority (Smith et al, 2013), can feel demoralized in a competitive environment (Shedlosky-Shoemaker and Fautch, 2015) resulting in suffering from imposter syndrome characterized by "persistent thoughts of intellectual phoniness" (Hutchins & Rainbolt, 2016) and eventually change courses. A study by Ellis, Fosdick and Rasmussen (2016) suggests that after taking Calculus I women are

1.5 times more likely to switch to a non-STEM field compared to their male counterparts with the same level of preparation.

Experience of women in the Maritime industry is in early stages of research. The work reported by Mackenzie (2015) on the challenges faced by women in this sector, are exacerbated due to working off shore or on board ships. In addition, the female role models in this sector have compromised by not having a family or by becoming "one of the boys" to achieve high level positions. This is counterproductive, as it reinforces perceptions of the maritime industry as unsuitable for women. In the more recent work presented by Bhirugnath-Bhookun & Kitada (2017) male ex-seafarers who often occupy managerial positions are not used to working with women and can be overtly discriminating towards women.

Interestingly, all of these apply to engineering as well despite of all the campaigns launched to challenge the under-representation of women in engineering. According to WISE (2017) girls make their choices based on the career opportunities that studying a STEM subject will offer. Therefore, to increase female recruitment in engineering it is vital that they are aware of the career opportunities as well as flexible working associated with engineering and navigation careers.

METHOD AND DATA COLLECTION PROCEDURE

We conducted focus groups with female undergraduate engineering and navigation students to understand their choices and experiences. The advantage of the focus group method was that it facilitates interaction, allowing for the sharing of experiences and views. This can generate conversation and the raising of further topics and ideas that would not necessarily arise in a one-to-one interview for example (Bryman, 2012). However, the limitations are the sample size, therefore, we should treat the results with caution.

The project received ethical approval from the Faculty Human Research Ethics Committee. Sixteen female students initially volunteered, with twelve eventually participating in the two focus groups. The first group comprised civil engineering students and the second was predominantly mechanical engineering students, but included one navigation student. All students were in their third year of study and some had completed an industrial placement year. The duration of the focus groups was approximately one and a half to two hours. Each focus group was co-ordinated by two facilitators and a scribe – two women and one man.

The focus groups were audio recorded and transcribed verbatim. All the participants were briefed and then asked to sign a consent form informing them that they could leave at any time during the process.

The topics of the focus group questions were focussed on why women had chosen their particular field of engineering or navigation and explored their experiences in the School of Engineering at the University of Plymouth.

RESULTS

The focus group data was analysed by transcribing the audio recordings and using a thematic approach. A number of themes emerged from the responses

and these were grouped according to their relationship to i) choice of degree subject and ii) the experiences of studying it.

Choice of degree subject

The group interviews began by asking the participants what had led them to choose to study engineering (and in one case, navigation). It was possible to identify common themes that had constrained or enabled their choices. Barriers included the 'invisibility' of engineering as a study and career option for girls; a lack of positive encouragement to consider engineering; the belief that engineering is only for high achievers in mathematics and reactions from others confirming the view that engineering is not a conventional choice for girls.

Awareness of engineering and navigation

Many of the women said they had chosen engineering because they are good at science and maths and found it to be a discipline that combined these interests. However, the majority of participants agreed that engineering had not been presented to them as an option to aspire to whilst they were school girls. Several of the participants mentioned that their choice for engineering was made at a very late stage in the university application cycle. In some cases, this was expressed as coming to engineering almost by accident and chance:

> *I saw a prospectus in the library in my new school and found engineering there. You don't even know it* (engineering) *is a thing that exists!* (Mechanical engineering student)

For this reason, most participants agreed that more should be done in schools to raise awareness of engineering and the school subjects needed to access higher education study.

The image of engineering

Many participants agreed that most people are not sure what an engineer does, or there is a common misperception that an engineer is a car mechanic

> **Participant 1**: *But no-one really understood what an engineer was either. So I still remember one of the girls like "oh what are you doing when you leave?" I was like: "Oh I'm going to uni, I'm going to study mechanical engineering" and she was like "so you're going to fix cars and stuff?" I was like "not really", I'm like: "I'm more likely to be designing them than fixing them, but sure, whatever! So they didn't understand what I was doing at all.*
> (Mechanical engineering students).

Conversely, some participants mentioned that engineering is perceived as a 'difficult' subject to get into – particularly because of the belief that you need to be a high achiever in mathematics:

Encouragement by family

However, several of the participants had relatives who were engineers or had some connection to engineering. In most of these cases, they had often been encouraged to consider engineering:

…actually it was my mum. She said if she had her time again she'd go and be an engineer. And I found that… I was like: "well what is engineering then?" So yeah, looked into it and thought actually this could be quite interesting (Mechanical Engineering student).

An inauthentic choice for girls?

Some of the women had faced reactions from others to their choice of A-levels or degrees, whether this was surprise, or bemusement. This served to remind them that their choice is atypical:

…I was met with surprise when I picked maths and physics A level, doesn't seem natural. In a way it's nice, 'cause people are impressed. But it shouldn't be any different" (Civil engineering student).

Experiences of studying the degree

Generally, participants talked in positive terms about their study experience. Most participants agreed that they have equal status with men on their degree and that there is no difference in the way the sexes are treated. However, several themes emerged that portrayed a challenging learning environment for women students. Key amongst these was the belief that male students feel threatened by women on the course; the necessity for women to earn credibility, and the costs faced by women as a result of positive action measures.

Confidence and competition

There was a high level of agreement that male students tend to be more confident in their abilities than women students and that the men feel a need to demonstrate their superiority:

Participant 2*: Yeah they do, they think they're more superior. And they, like I had a group … there was 7-8 of us in the design module and it was brutal for me. I absolutely hated it, and I just felt this big ….. I was like I'm good at design and you lot are just making it….it was hellish, it stripped all your confidence and it makes you feel like "I just don't belong here - shall I choose something else?"*
(Mechanical Engineering student)

Proving yourself

The fact that many male students appear to rate their abilities more highly than their female peers, intensifies the additional effort that women must make in order prove their right to be on the degree and in so doing, 'earn' their place. One participant, who is older than most of her peers, described her experience of working with her younger, all-male, group:

One of the boys was talking to me but he didn't think I could bring anything much to the party, but I brought a prototype and my design and he was like "well if you've done all that, let's do that". I did spend the rest of time organising them and they were perfectly happy to be organised. But then I'm older and they're younger, so there's probably that imbalance too and I'm maybe a bit more organised naturally (Civil engineering student).

Tolerating banter

Robnett (2016) has described how women respond to gender discrimination perpetrated by their male peers. Responses can range from active coping to passive coping. Whereas active coping might involve reporting an incident, passive coping involves accepting it, or denying that the behaviour constitutes discrimination. The passive coping response was reflected here in the idea that 'banter' must be tolerated:

> ***Participant 1****: the guys come out with stuff that I just know they're just being sarcastic 'cos they try to get a reaction out of me. They know… they're starting to learn now that I just won't bite … that prepares me for anything anyone else has got to say…… It is just pure banter. They treat everyone the same. They pick on each other ….They can say something about me being the only girl, but they're not getting the reaction they want. Not had any serious discrimination.*

Positive action backlash*:*

On the question of tackling gender imbalances in engineering, most participants supported the idea of actively encouraging schoolgirls to consider choosing 'non-traditional' subjects for A-level and beyond. However, many agreed that once they have reached the university stage, women have equality with men, or sometimes even an added advantage, therefore, extra support is not needed:

> *I think the outreach is a good thing, with being the STEM ambassadors, potentially going out to schools and encourage girls in to engineering, I think that's good…..I think we all expect to have to measure up …..I know they might look at your CV twice, but you'd like to hope that you've got to be as good as the male applicant to get the job …. I don't think any of us would want to be handed it on a plate would we?* (Civil engineering student).

A widely held view was that women's 'unfair advantage' is particularly visible when students are being selected for industrial placement and graduate jobs:

The desire to be accepted as an 'authentic' engineer

For many participants it seems that initiatives such as Women Engineering Society are perceived to be at odds with the need to fit in and be the same as everybody else. The desire to be accepted simply as an engineer, not a 'woman engineer', was expressed frequently, as is the need to get the placement/job on merit:

> *you're like… "I don't want to be looked at because I'm a woman in engineering, I just want to be looked at as an engineer". So it's definitely something you get a lot of….."Oh you'll be fine, you're a woman". You're like "OK*" (Civil engineering student).

Even though there was a consensus amongst participants that they want to be accepted as engineers, not as *women engineers*, as Faulkner (2006) points out, women can be sexually visible in a way that the men are not. This can be costly to women engineers.

CONCLUSION AND RECOMMENDATIONS

Our findings show that a long history of outreach and support initiatives has had limited impact in increasing female participation and progression in engineering. Schools are not necessarily giving girls the opportunity to find out about

engineering and navigation options. Those women who *do* become engineering students feel the need to gain credibility and make compromises in order to 'fit in'. Positive action initiatives and support networks have had limited impact in tackling the underlying gendered culture of the disciplines. Furthermore, women are discouraged from participating in 'women's initiatives', because they are seen to give them an unfair advantage, or imply that women need extra help. The perception that such initiatives are discriminatory or 'anti-men' leaves women no basis on which to act collectively, or even in partnership with men. However, without positive action, nothing changes.

We must further explore students' perspectives in order to find a way forward. In our future work, we will be conducting male-only focus groups in addition to female-only focus groups. We will also be piloting an equality, diversity and inclusion committee for undergraduates encouraging equal male female representation.

Equality initiatives of the future must be sensitive to the unintended consequences noted here. One avenue for further exploration is to articulate a role for men in promoting gender equality. Men need to be included in promoting equal opportunities and both men and women need to be aware of why it is still necessary to take positive action to bring more women into the Engineering and navigation professions.

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